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Neural Network in a Joint HAPS and Terrestrial Fixed Broadband System

S. H. Alsamhi
Department of Electronics Engineering, IIT (BHU)
Varanasi, India

N. S. Rajput
Department of Electronics Engineering, IIT (BHU))
Varanasi, India

Abstract— **this paper sheds the light on coexistence and sharing between high altitude platform system (HAPS) and WiMAX system. Spectrum etiquettes used for combined HAP and terrestrial fixed broadband systems. Spectrum etiquettes used to enable the coexistence of HAP and terrestrial systems. Nowadays, A HAPS becomes a recognized system in this band 5.75GHz.Therefore; terrestrial links are one of the most considerable interference with the HAP gateway station (HAPGS) links. Hence, coexistence of HAPS and WiMAX requires separation distance which must be achieved in terms of both co-channel and adjacent channel frequencies. Coexistence of the terrestrial subscriber station HAP and A HAPGS is impossible without interference mitigation and spectrum etiquettes. Therefore, these systems can work effectively and efficiently. Therefore the QoS sustain high. Based on the study results, the minimum separation distance should be 15 to 18 km away from the reference point. The isolation technique is applied in the distances less than 15 km and above 18 km in order to mitigate the interference. Consequently, the maximum isolation values should be 30.92 dB and 13.4 dB inserted between the WiMAX Station and HAPGS.**

Keywords- ANN; HAPS; Coexistence; CINR;INR; WiMAX.

I. INTRODUCTION

Now days, communication services are in high demand and widely used. It means that a large amount of wireless infrastructure is required to meet the significant demand on the radio spectrum. This incrimination for wireless applications attracted researchers in finding new technology to be part of telecommunication infrastructure in future.

Consequently, HAPS as a novel technology is proposed to be the third layer of telecommunications infrastructures after satellite and terrestrial services[1]. The importance of this technology and its compatibility with other existing services led to conducting several researches [2-5] on investigating the coexistence, sharing and interference between HAPS and other services. A HAP stations (HAPs) are airships or platforms with a massive potential which foremost defined in 1997[6]. HAPs as a new solution for delivering wireless broadband , have been recently proposed for the provision of fixed, have suggested to as way to providing 3G mobile services in stratosphere at an altitude of 17 km to 21 km[7-9]. There are two types of links between the payload and the ground equipment: gateway link and user link Customer-premises equipment (CPE).CPE is any terminal and associated equipment located at a subscriber's premises and connected with a carrier's telecommunication channels at the demarcation point and refers to devices such as telephones, routers, switches, residential gateway (RG). As well as there are three proposed architectures for HAPS communication system: They are standalone HAPs system, integrated HAPs terrestrial system, and integrated terrestrial HAPs satellite system [10].

WiMAX provides an efficient technology for the communication between the flying HAP and the user on the ground. IEEE 806.16 standard focuses mainly on how to provide broadband connection at link layer and physical layer independent on the upper layers [11]. The scenario in Figure 1 includes the User Segment, Sky Segment, and Ground Segment. When HAP and terrestrial WiMAX are in the same coverage area, it is known as coexistence scenario. The HAP will be coexisting with a primary terrestrial system and give an effect to the system performance. Therefore the dynamic spectrum management is used to allow these systems to share the same frequency band and ensure that they can work together effectively and efficiently also share the same frequency 5.75GHz.

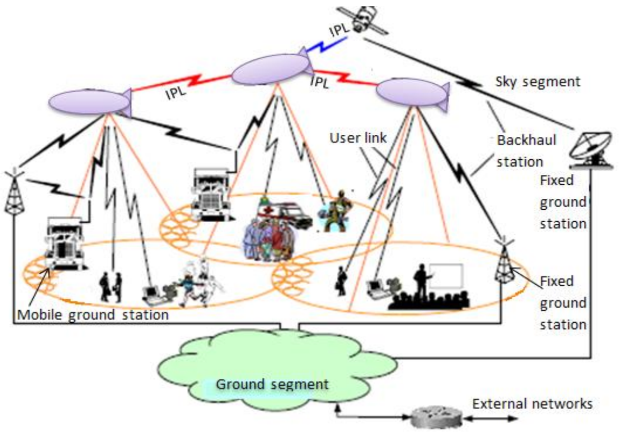

Figure 1. HAP Network architecture

This research paper is focused also on the scheme to control parameter such as transmit power to improve efficiency of the coexistence scenario. The paper is organized as follows; spectrum etiquettes are described in section II and terrestrial WiMAX system in section III. In section IV coexistence of HAP and WiMAX covers and performance coexistence is described in section V. Then the result and discussion are taken up in section V1 .Finally, section VII, conclusion of this work.

II. SPECTRUM ETIQUETTES

Coexistence performance of HAP and terrestrial fixed broadband systems depend in two spectrum etiquettes that are

intended for future applications. Spectrum etiquettes are based on the carrier to interference pulse noise ratio(CINR) and interference to noise ratio (INR) at the receiver. Spectrum etiquettes vary the transmitter power of the base station of newly activated system. Spectrum etiquettes which include INR and CINR used to improve coexistence of HAP with fixed broadband systems. When applying spectrum etiquettes to HAP system is degraded since it controls and limits the HAP transmitted power level [12]as well as CINR scheme performance better than INR.

CINR used to control the newly activated system and takes the CINR level at the receiver of incumbent user .newly active system power takes into account the gain of the user antenna in the direction of the interfering base station, significant of the interferences level reduce till the interference fall in to the side lobes of the antenna. Transmitter power reduce in HAP to boring the CINR up in order maintain the modulation threshold level. On the other hand, CINR of the terrestrial user on the beacon channel would.

INR uses to control the newly activated system downlink transmitted power. The INR with -10dB desired INR level forces the HAP system to transmit at very low transmitter power level to the terrestrial that for reduce outage probability.

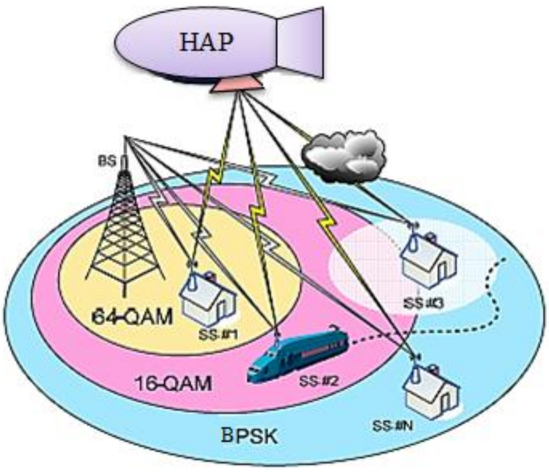

Figure 2. Modulation level in different level of HAP coverage area

Examined performance of the scheme and to determine the most appropriate modulation level to connect with guarantee that outage caused by interference pulse noise ratio remains below threshold level as shown in Figure 2.

III. TERRESTRIAL WIMAX SYSTEM

WiMAX, means Worldwide Interoperability for Microwave Access, is a technology that provides fixed and mobile internet access. WiMAX involves a base station that is normally mounted on top of the building or at some place high where it can provide optimum coverage. WiMAX rang is up to 30miles and achieves data rate up to 75Mbps. The original WiMAX standard is 80.16 specified WiMAX for the 10GHz to 66GHz. After the updating it became 802.16-2004 standard that specified for 2 to 11GHz range. WiMAX achieve better spectral efficiency as compared to other existing wireless communication technologies due to its high bandwidth feature. WiMAX is one of the essential features that 3G network must be address. The data transmission between two towers can be through a microwave transmission link and WiMAX base station can also be connected to the IP backbone network using a wired connection as shown in Figure 3. The communication between WiMAX base station and subscriber can be pointe to multipoint whereas communication between two or more WiMAX base station could be in the form of point to point line of sight.

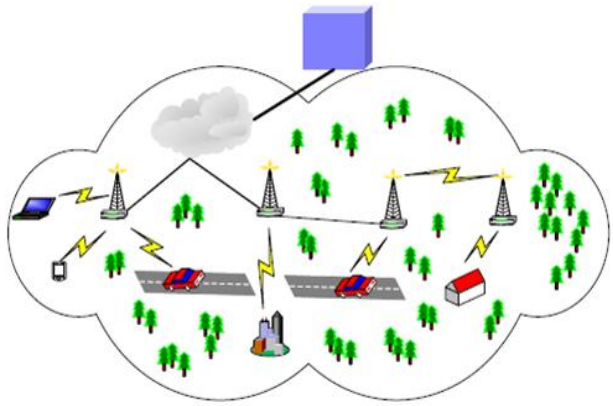

Figure 3. Terrestrial WiMAX networks

IV. COEXISTENCE OF HAP AND WIMAX

WiMAX (IEEE802.16a) has been suggested and widely accepted to provide future broadband services and may operate in unlicensed frequency bands. In same band WiMAX will face coexistence with other systems. The HAP base station is assumed to be located at an altitude of 17Km above ground with radius of coverage area equal to 30km.

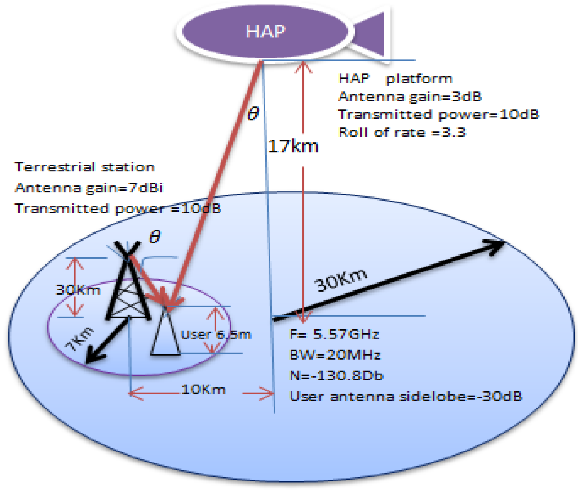

Figure 4. Coexisting HAP and terrestrial base station

In [13] the capability of HAP to serve larger coverage areas using considerably less ground infrastructure than conventional terrestrial systems. The system scenario consists of a single HAP base station and terrestrial WiMAX System located inside the HAP coverage area as in Figure 4. The terrestrial base station is located inside the HAP coverage area 10km away from the center of HAP coverage.

Coexistence means there are more than one system providing services in the same coverage area shared the same frequency band. The studies[14-16].As in[14], the coexistence between HAPS and TS during the catastrophe situation is possible. The main purpose of this coexistence scenario is to investigate the impact on either an existing HAP or terrestrial WiMAX system when another system using the same frequency band is activated. In both[14] and [15], the carrier to noise ratio (CNR) and carrier to noise plus interference ratio

(CINR) are calculated to find the performance of both terrestrial and HAPS services in order to investigate the possibility of coexistence between the two systems.

V. PERFORMANCE OF COEXISTANCE

It is very important to make two system works in same coverage area and share same frequency. In this research paper WiMAX system is selected because of it works in wireless broadband system. we focused also on the scheme to control parameter such as transmit power to improve efficiency of the coexistence scenario, an Omni-direction antenna is consider for the terrestrial system, which has a small circular coverage area for simplicity. There are two variable spectrum etiquettes schemes called CINR and INR based scheme which getting to improve coexistence performance between HAPS system and terrestrial WiMAX system.

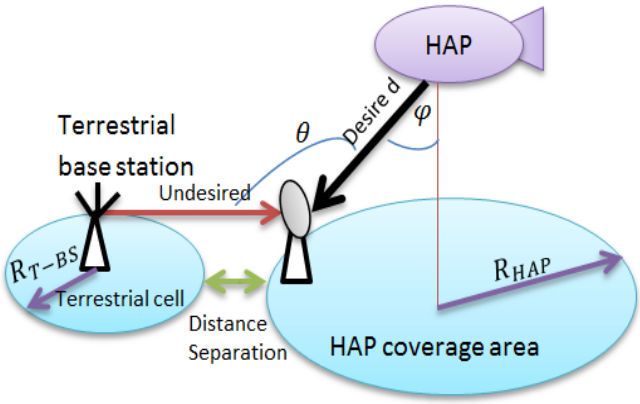

Figure 5.Coexistence model providing WiMAX from HAP

The INR power control scheme was used to investigate coexistence performance so that the second activated system as shown in figure 5. HAPS can transmit power as long as the INR less than threshold. Threshold requirement is -10dB.The INR can be calculated by (2),

$$\mathrm{INR} = \mathrm{I/NF} = (P_H A_H(\emptyset) A_U(\theta) PL_T)/N_F \quad (2)$$

$$\mathrm{CINR} = \mathrm{C/I+N} = P_H A_H(\varphi) A_U(\theta) PL_H / N_F + P_T A_T A_U(\theta) PL_T \quad (3)$$

Where N_F is the thermal noise power, P_H is power transmitted of respected base station, $A_H(\emptyset)$ is the transmit gain of base station antenna at an angle $\emptyset$ with respect to its boresight and the receive gain of the user antenna $A_U(\theta)$ at an angle θ away from it bore sight are approximated by a cosine function raised to power roll-off factor n with a flat side lobe level. P_T is transmission power of terrestrial BS, and A_T is the transmission gain of terrestrial BS. They are represented in (3) and (4) respectively [17]

$$A_H(\emptyset) = G_H(\max[\cos(\emptyset)^{n_H}, s_f]) \quad (3)$$

$$A_U(\theta) = G_U(\max[\cos(\theta)^{n_U}, s_f]) \quad (4)$$

Where G_H and G_U represent the boresight gain of the base station antenna and receive user antenna, and s_f represent a flat side lobe floor in dB. Initially, we specify that the -10dB roll-off beam width of HAP antenna is equal to diameter of its coverage area. Therefore more power can be certainly radiated inside the HAP coverage and produce less interference to terrestrial WiMAX system. PL_T Represent the linear path loss value given by (5), reference by [18]:

$$PL_T = PL_m + \Delta PL_f + \Delta PL_h \quad (5)$$

$$PL_m = A + 10\gamma\log_{10}(d/d_0) + s \quad (6)$$

$$A = 20\log_{10}(4\pi d_0/\lambda) \quad (7)$$

Where PL_m the median path loss in dB and S is represents the shadowing effect. The typical value of standard deviation for s is between 8.2 and 10.6dB.depending on the tree density type.ΔPL_f Represent the frequency correction in dB given by (8),

$$\Delta PL_f = 6\log(f/2000) \quad (8)$$

Where F is frequency in MHz, PL_T Covers three common terrain categories described as category A, B and C [18].

VI. NEURAL NETWORK

Recently, artificial neural networks (ANNs) have been applied to many diverse problems. ANNs are one tool of artificial intelligence (AI). An ANN is a massively parallel distributed processor that stores experimental knowledge; this knowledge is acquired by a learning process and is stored in the form of parameters of the ANN [19].

The ANN consists of a number of neurons arranged in a particular fashion. A nonlinear model of the artificial neuron is shown in figure 6. The three basic elements of neuron are weights, summing junction, and the activation function.

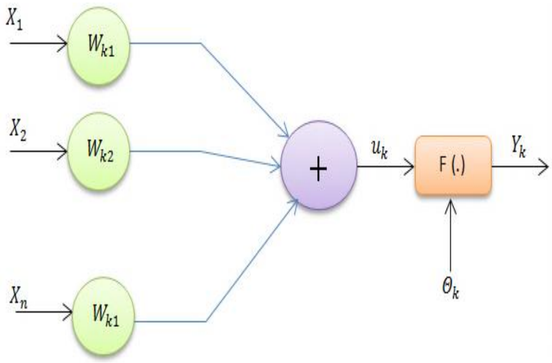

Figure 6. Model of Artificial neuron

Different activation functions include hard limit, linear, log-sig. threshold θ_k can be considered as one of the weight. The ANN consists of more than one neuron. The output of a neuron k is given by:

$$u_k = \sum_{j=1}^{n} W_{kj} X_j \quad (9)$$

$$Y_k = f(u_k - \theta_k) \quad (10)$$

Where X_j (j=1,………., p) are the input, W_{kj} are weights, θ_k is the threshold, f(.) is the activate function, and Y_k is the output of neuron.Characteristics of ANNs are massively parallel distributed architecture, ability to learn and generalize, fault tolerance, nonlinearity, and adaptively. The learning in ANNs can be unsupervised or supervised.

The ANN consists of a number of neurons arranged in a particular fashion. The three basic elements of a neuron are the synaptic weights (or weights), the summing junction, and the activation function. In Fig.6 explains the fundamental component of the ANN, an artificial neuron.

VII. RESULT

Platform position allows HAPS based systems to provide better channel condition because it achieved advantages over the other systems. The interference signal is intercepted by hills and for buildings in the majority of cases when two stations located more than 100km.Under clear sky condition, losses only consist of atmospheric absorption loss, free space loss and

feeder loss. As well as we consider WiMAX as example for terrestrial broadband system and its coexistence with HAPS. Calculations are done by using MATLAB software following the ITU recommendations. The evaluation of interference is in clear sky and rainy condition. Study of relationship between interference to noise ratio and azimuth angle as well as elevation angle is very important to mitigate interference from HAPGS to TS. The separation distance that required for coexistence of HAPGS and TS in clear sky condition is shown in Figure 7. The azimuth Angles considered includes 300,600,900, and 1200. It can be seen that I/N decreases when separation distance increases for various azimuth angle. For azimuth of 300, or any azimuth less than 600, the minimum separation distance required to obtain optimum I/N is 182 km. For azimuth of 600, 900, and 1200, the minimum separation distance required to obtain optimum I/N are118 km, 51km and 22km respectively. The separation distance required for coexistence of HAP and Terrestrial Stations.

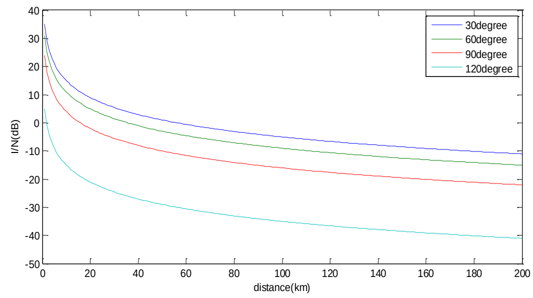

Figure 7. separation distance required for coexistence

It is suitable for the propagation of the terrestrial WiMAX system and HAP system is in line of sight. Vary the modulation scheme of HAP from BPSK modulation to 64QAM modulation scheme as shown in Figure 8, 9. Therefore the terrestrial WiMAX and HAP can work effectively in coexistence coverage. In the case of BPSK modulation for HAP, the power transmit from the HAP is lower than power transmit from the terrestrial WiMAX such as power transmit from WiMAX is 7.5284 but the power transmit from HAP is 4.5503.Therefore no need to adjust terrestrial power, the signal to noise ratio isn't changed.

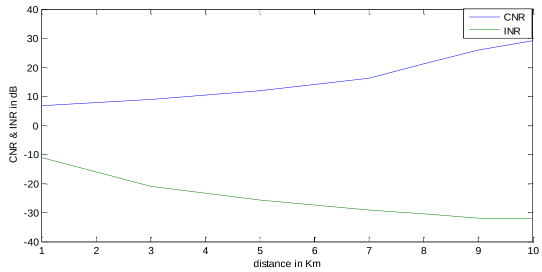

Figure 8. spectrum etiquettes in BPSK modulation for varies distance

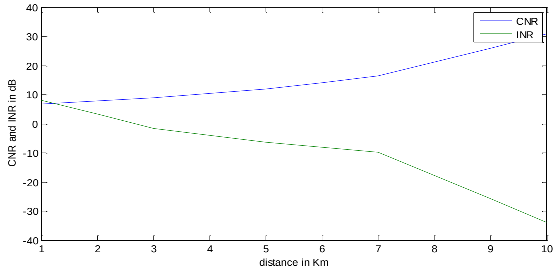

Figure 9. spectrum etiquettes in 64QAM modulation for varies distance

That because using of BPSK modulation on HAP and the interference to noise ratio is lower than threshold. In the case of 64QAM Modulation for HAP, the transmit power from HAP is higher than transmit power from terrestrial WiMAX 7.5793, 23.7982 respectively. Therefore, I/N ratio is above of the threshold, the carrier to noise ratio changed, and the terrestrial base station of WiMAX needs to increase transmit power for coexistence performance of these systems. For various distance in 64QAM shown when the carrier to noise ratio increases the distance between HAP and user increase as well as, the interference to noise ratio decrease when the distance between HAP and terrestrial WiMAX is increase. When the user is far away from HAP is 7km, the interference decrease drastically because the user start to go out of the HAP coverage and transmit power of terrestrial system is getting higher.

VIII. CONCLUSION

The interference caused at the terrestrial station from HAPS and HAPGS is evaluated with all the results as computed using MATLAB. In case of interference examined from HAPGS to TS, the optimum I/N decreases when the separation distance increases for various azimuths and for azimuth equal to 150^0 or above, the minimum separation distance to obtain optimum I/N is 5km. we have looked at the coexistence performance and capability of HAP and terrestrial WiMAX systems. Coexistence performance was evaluated in fixed separation distance case between HAP and terrestrial base station is 10km, as well as the result show that the hap and terrestrial system share the same frequency band. The interference from HAP system to terrestrial WiMAX decrease and both system can work effectively because the transmit power from terrestrial WiMAX can be adjusted to provide high power. The result show that In case of using BPSK modulation, the transmit power from HAP is lower than transmit power from terrestrial. In the other case (64QAM), power control scheme is require to adjust because the transmit power from HAP is great. When the power on terrestrial WiMAX can be increase, then the interference to noise ratio will decrease. Therefore the coexistence will be better and QoS enhanced.

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